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**Keidar**

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(54) **MAINTENANCE OF MOBILE DEVICE RF BEAM**

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(51) **Int. Cl.**

***H04W 24/00*** (2009.01)
***H01Q 3/26*** (2006.01)
***H01Q 1/24*** (2006.01)

(52) **U.S. Cl.**

CPC ................. ***H01Q 3/26*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 1/246*** (2013.01)

(58) **Field of Classification Search**

CPC ........ H01Q 1/1257; H01Q 1/245; H01Q 3/24
USPC ....................................................... 455/456.1
See application file for complete search history.

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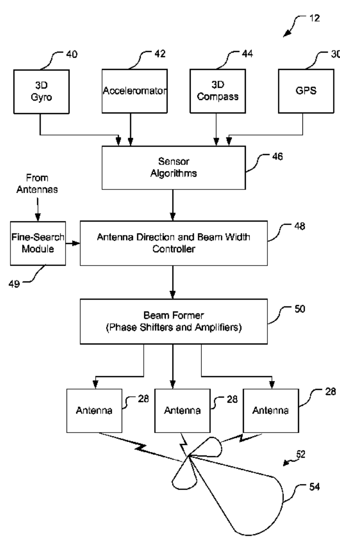
(57) **ABSTRACT**

A mobile wireless communication device includes: a communication device housing; an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing signals and to receive electromagnetic energy of incoming signals; a beam-altering module communicatively coupled to the antenna module and configured to alter a three-dimensional direction that the directional beam is pointing; and a three-dimensional orientation sensor module communicatively coupled to the beam-altering module and configured to provide at least one indication of three-dimensional orientation information associated with the communication device; where the beam-altering module is configured to receive the at least one indication of three-dimensional orientation information associated with the communication device and to use the at least one indication of three-dimensional orientation information associated with the communication device to alter the three-dimensional direction that the directional beam is pointing.

**31 Claims, 7 Drawing Sheets**



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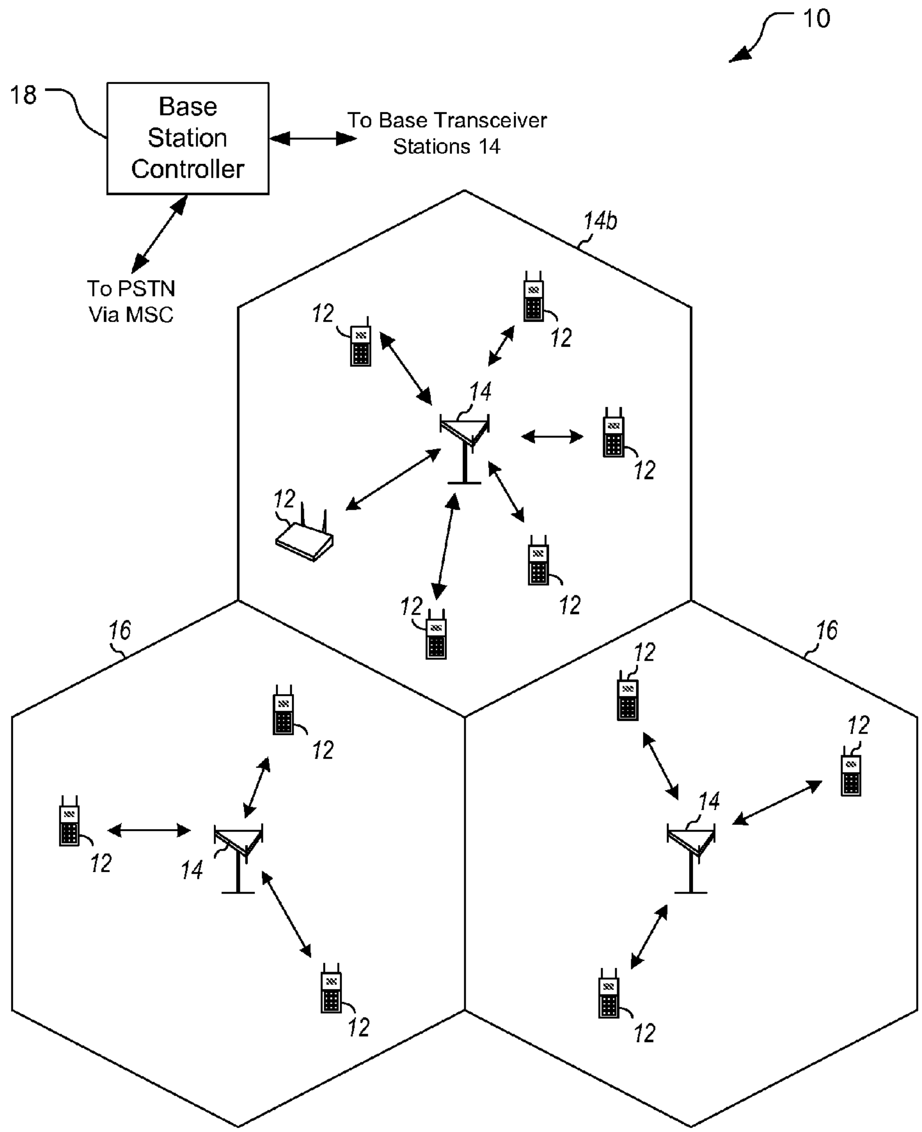
10
18
Base
Station
Controller
To Base Transceiver
Stations 14
To PSTN
Via MSC
14b
12
14
16
12
14
16
12
14
12

FIG. 1

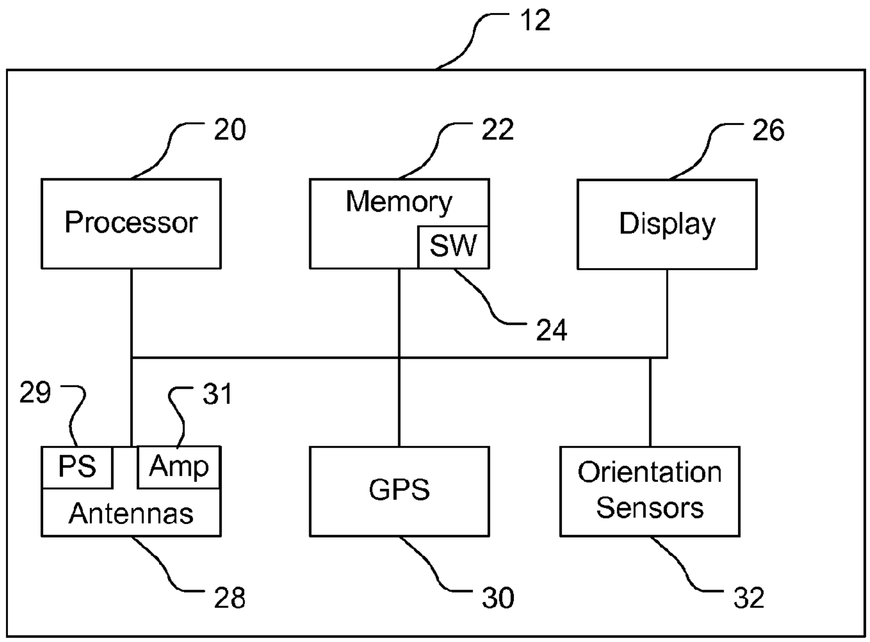
12
20
Processor
22
Memory
SW
24
26
Display
29
31
PS
Amp
Antennas
28
GPS
30
Orientation Sensors
32

FIG. 2

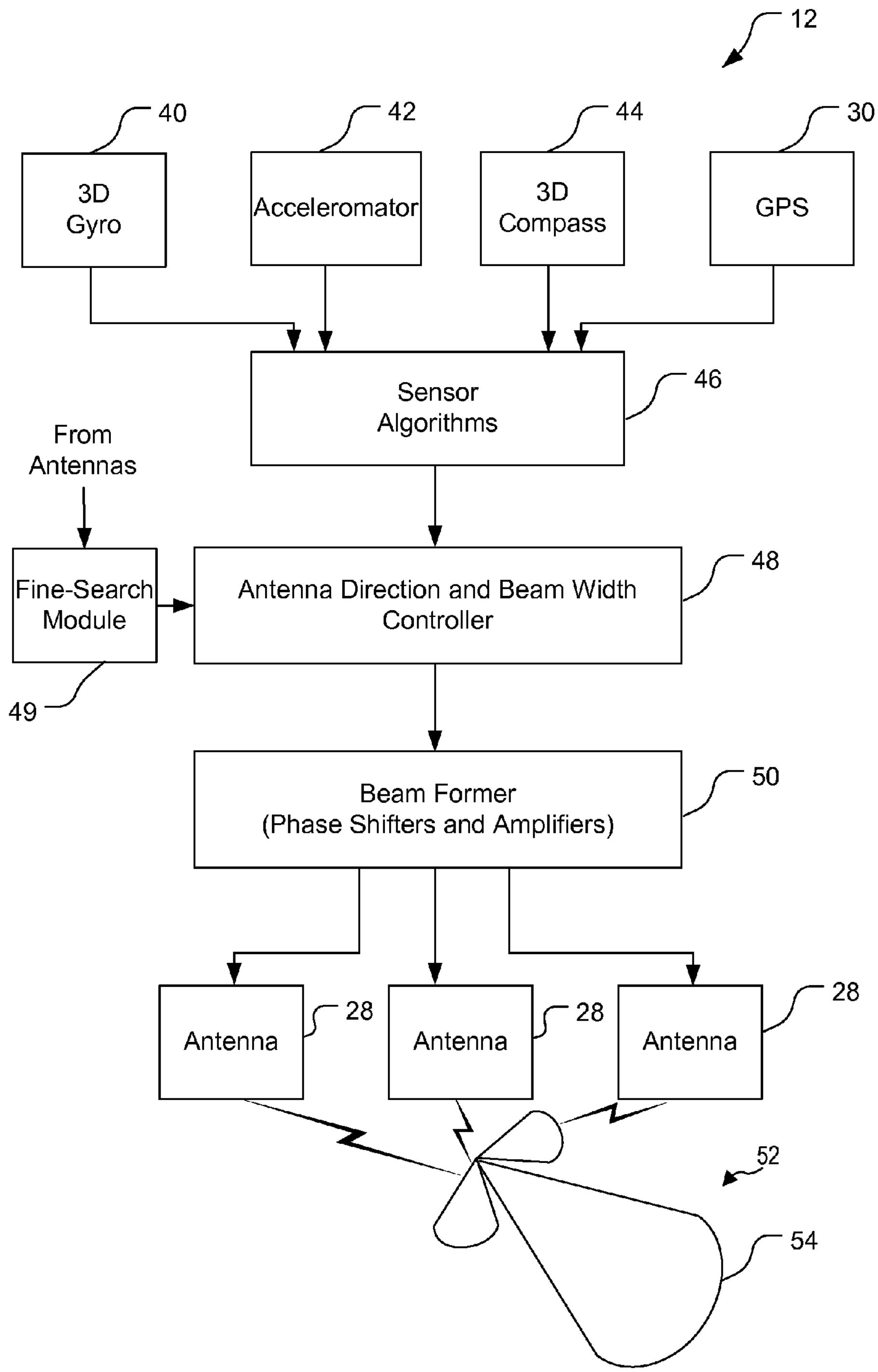
12
40
42
44
30
3D Gyro
Accelerometor
3D Compass
GPS
Sensor Algorithms
46
From Antennas
Fine-Search Module
Antenna Direction and Beam Width Controller
48
49
Beam Former (Phase Shifters and Amplifiers)
50
Antenna
28
Antenna
28
Antenna
28
52
54

FIG. 3

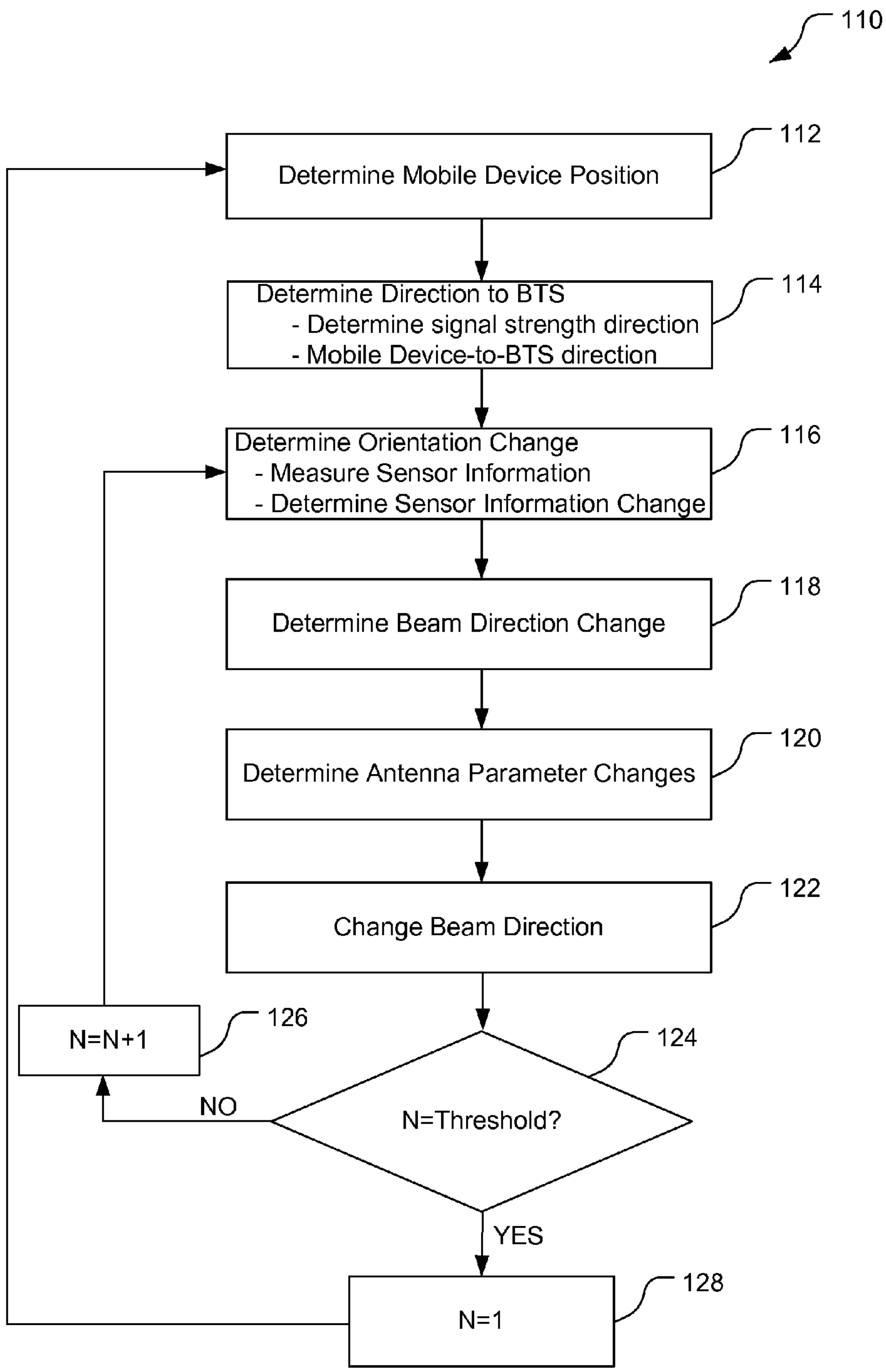
110
Determine Mobile Device Position
112
Determine Direction to BTS
- Determine signal strength direction
- Mobile Device-to-BTS direction
114
Determine Orientation Change
- Measure Sensor Information
- Determine Sensor Information Change
116
Determine Beam Direction Change
118
Determine Antenna Parameter Changes
120
Change Beam Direction
122
N=N+1
126
N=Threshold?
124
NO
YES
N=1
128

FIG. 4

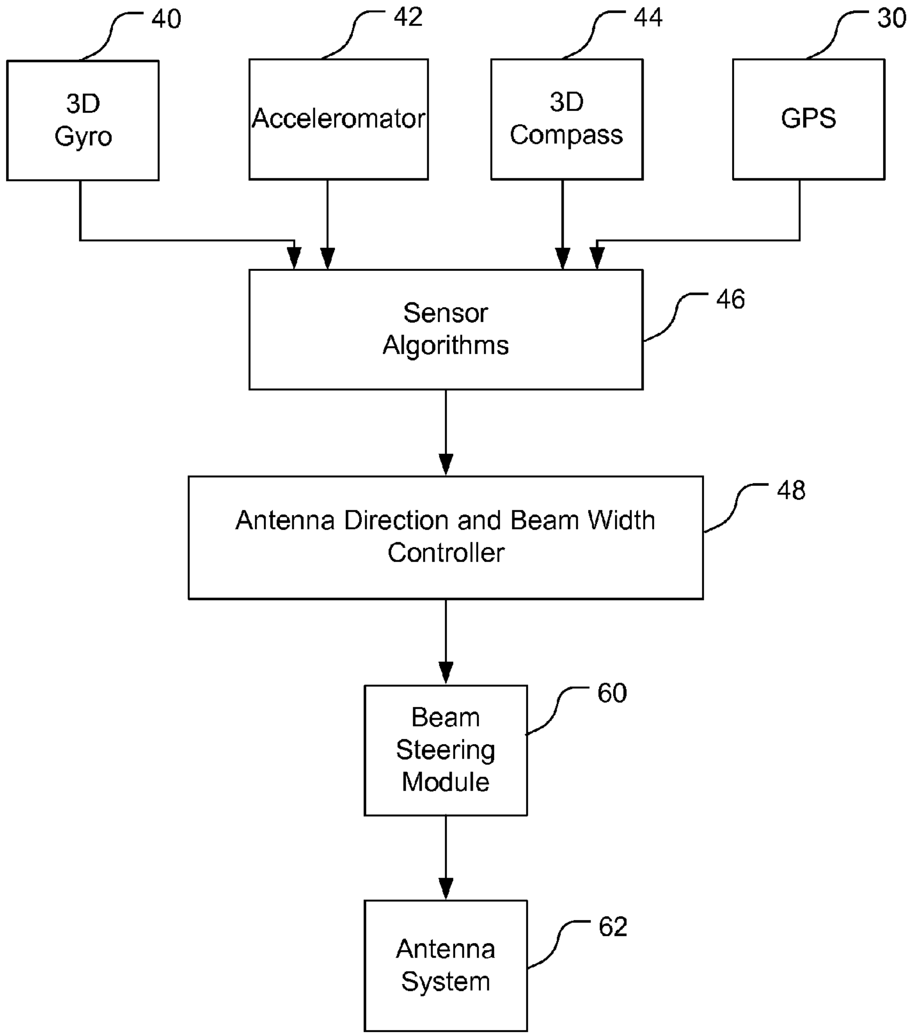
40
3D
Gyro
42
Accelerometer
44
3D
Compass
30
GPS
Sensor
Algorithms
46
Antenna Direction and Beam Width
Controller
48
Beam
Steering
Module
60
Antenna
System
62

FIG. 5

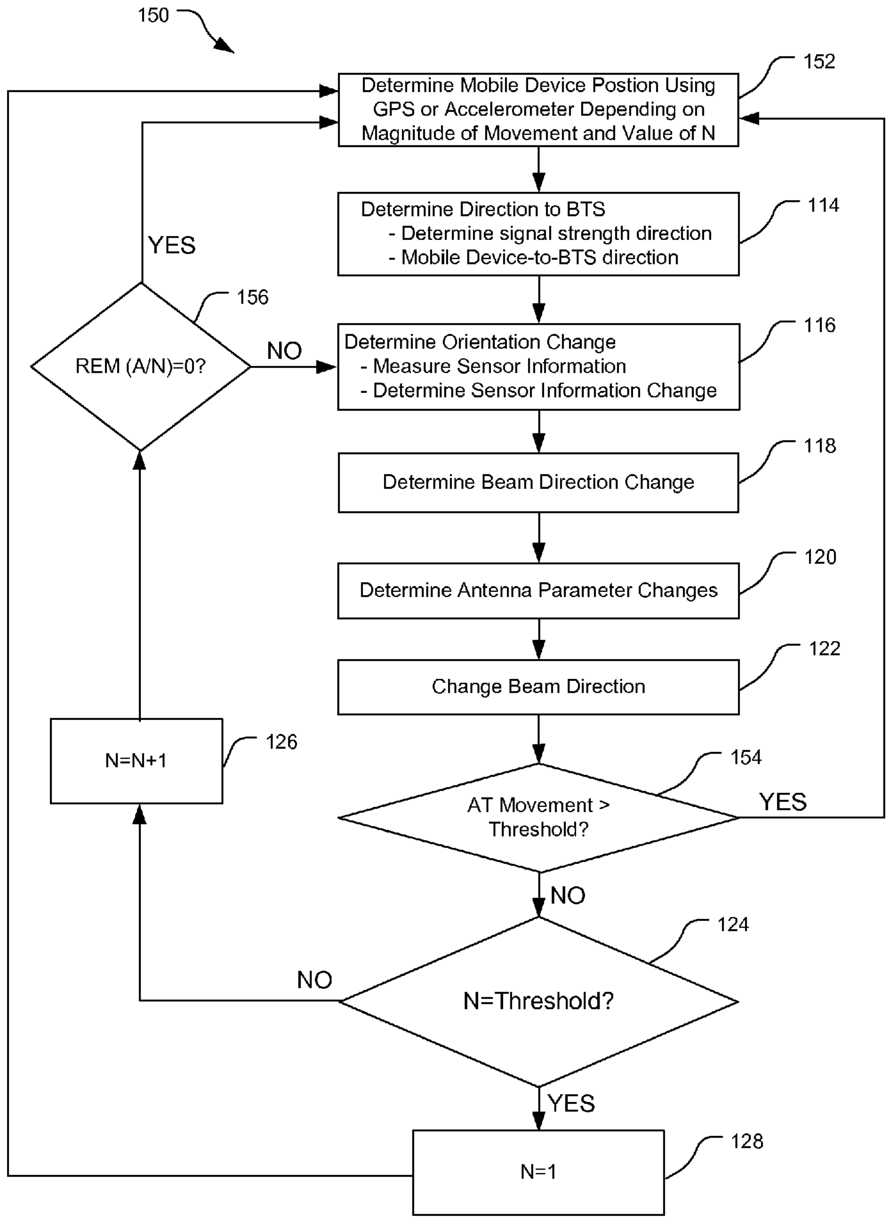
150
Determine Mobile Device Postion Using GPS or Accelerometer Depending on Magnitude of Movement and Value of N
152
Determine Direction to BTS
- Determine signal strength direction
- Mobile Device-to-BTS direction
114
YES
156
REM (A/N)=0?
NO
Determine Orientation Change
- Measure Sensor Information
- Determine Sensor Information Change
116
Determine Beam Direction Change
118
Determine Antenna Parameter Changes
120
Change Beam Direction
122
N=N+1
126
154
AT Movement > Threshold?
YES
NO
124
NO
N=Threshold?
YES
N=1
128

FIG. 6

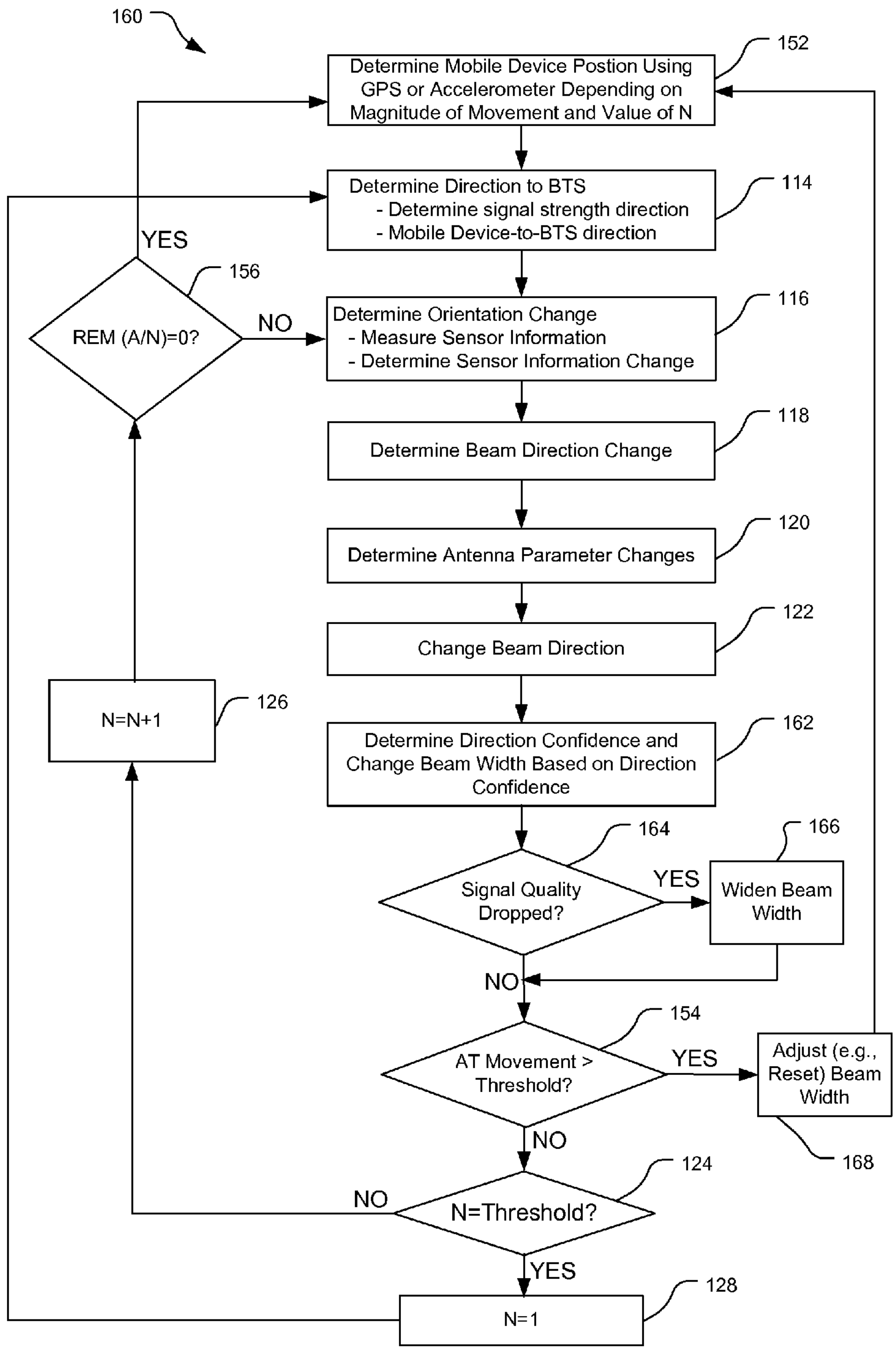
160
Determine Mobile Device Postion Using GPS or Accelerometer Depending on Magnitude of Movement and Value of N
152
Determine Direction to BTS
- Determine signal strength direction
- Mobile Device-to-BTS direction
114
YES
156
REM (A/N)=0?
NO
Determine Orientation Change
- Measure Sensor Information
- Determine Sensor Information Change
116
Determine Beam Direction Change
118
Determine Antenna Parameter Changes
120
Change Beam Direction
122
N=N+1
126
Determine Direction Confidence and Change Beam Width Based on Direction Confidence
162
164
166
Signal Quality Dropped?
YES
Widen Beam Width
NO
154
AT Movement > Threshold?
YES
Adjust (e.g., Reset) Beam Width
NO
168
124
NO
N=Threshold?
YES
128
N=1

FIG. 7

# MAINTENANCE OF MOBILE DEVICE RF BEAM

## CLAIM OF PRIORITY UNDER 35 U.S.C. §119

The present Application for Patent claims priority to Provisional Application No. 61/522,068 entitled "DIRECTION MAINTENANCE OF MOBILE DEVICE RF BEAM USING MOTION SENSORS" filed Aug. 10, 2011, and assigned to the assignee hereof and hereby expressly incorporated by reference herein.

## BACKGROUND

Wireless communication devices are incredibly widespread in today's society. For example, people use cellular phones, smart phones, personal digital assistants, laptop computers, pagers, tablet computers, etc. to send and receive data wirelessly from countless locations. Wireless communication devices are typically served by base transceiver stations (BTSs). With numerous users served by a single BTS, noise and interference between the mobile devices and the BTS as well as with other signals make the transmission of information more difficult, e.g., to transmit the data accurately. Further, the noise and interference reduce the throughput of the wireless communication systems, e.g., due to omni-directional transmission in which each device contributes to the noise of its counterparts.

One technique employed currently for helping to reduce the noise and interference and increase data throughput in wireless communication networks is to beam form from the BTS. In this technique, an antenna beam from the BTS is produced in a direction for a particular wireless communication device in order to use a higher directivity antenna pattern, thereby allowing a reduction in transmission power and a reduction in noise and interference for communications or data transmission from the BTS to a particular mobile device.

Another technique to combat noise and interference is to use a mechanically steered antenna. In this example, the antenna can be physically moved at the BTS to point in a desired direction, e.g., toward a satellite.

Another technique to combat noise and interference is to use a mechanically steered antenna. In this example, the antenna can be physically moved at the BTS to point in a desired direction, e.g., toward a satellite.

Another technique for combating interference is to use multiple input and multiple output antennas. The use of multiple antennas on both the transmission and receiving ends allows multiple signals to be combined to provide a combined signal that can be processed to help eliminate the noise and interference effects.

## SUMMARY

An example of a mobile wireless communication device includes: a communication device housing; an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing signals and to receive electromagnetic energy of incoming signals; a beam-altering module communicatively coupled to the antenna module and configured to alter a three-dimensional direction that the directional beam is pointing; and a three-dimensional orientation sensor module communicatively coupled to the beam-altering module and configured to provide at least one indication of three-dimensional orientation information associated with the communication device; where the beam-altering module is configured to receive the at least one indication of three-dimensional orientation information associated with the communication device and to use the at least one indication of three-dimensional orientation information associated with the communication device to alter the three-dimensional direction that the directional beam is pointing.

Implementations of such a device may include one or more of the following features. The beam-altering module is configured to determine a direction from the device toward a base transceiver station. The indication of orientation information associated with the communication device indicates a three-dimensional orientation of the communication device, the communication device further includes a satellite positioning system module configured to determine a location of the device, and the beam-altering module is configured to determine a location of the base transceiver station and being configured to determine the direction from the device toward the base transceiver station using the location of the device, the location of the base transceiver station, and the orientation of the communication device. The at least one indication of three-dimensional orientation information associated with the communication device is at least one indication of change in three-dimensional orientation of the communication device, the communication device further includes a satellite positioning system module configured to determine a location of the device, and the beam-altering module is configured to use the location of the device in addition to the at least one indication of change in three-dimensional orientation of the communication device to alter the three-dimensional direction that the directional beam is pointing. The beam-altering module is configured to determine the direction from the device toward the base transceiver station based on strengths of received signals from different receive paths.

Additionally or alternatively, implementations of the device may include one or more of the following features. The at least one indication of three-dimensional orientation information associated with the communication device is at least one indication of change in three-dimensional orientation of the communication device. The orientation sensor module includes at least one of (1) a three-dimensional gyroscope sensor, or (2) a three-dimensional compass and a gravity sensor. The beam-altering module includes a beam-forming module and the antenna module includes a phased-array antenna that includes antenna elements and a phase module configured to set phases for corresponding ones of the antenna elements to point the directional beam in a desired direction. The beam-altering module includes a beam-steering module configured to direct the directional beam provided by the antenna module. The beam-altering module is configured to adjust a width of the directional beam in response to movement of the device indicated by the three-dimensional orientation sensor module.

Another example of a mobile wireless communication device includes: an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing communication signals for reception by a base transceiver station and to receive electromagnetic energy of incoming signals from the base transceiver station; direction means for determining a direction of the base transceiver station relative to the communication device; orientation means for determining three-dimensional orientation information associated with the communication device; and altering means, communicatively coupled to the antenna module, the direction means, and the orientation means, for causing the antenna module to set a three-dimen-

sional direction that the directional beam is pointing based on the three-dimensional orientation information from the orientation means.

Implementations of such a device may include one or more of the following features. The orientation information associated with the communication device indicates a three-dimensional orientation of the communication device, the direction means include a satellite positioning system module configured to determine a location of the device, and the altering means are further for determining a location of the base transceiver station and determining the direction from the device toward the base transceiver station using the location of the device, the location of the base transceiver station, and the three-dimensional orientation of the communication device. The orientation information associated with the communication device is a change in orientation of the communication device, the direction means include a satellite positioning system module configured to determine a location of the device, and the altering means are further for using the location of the device in addition to the orientation information to alter the three-dimensional direction that the directional beam is pointing. The direction means are configured to determine the direction of the base transceiver station relative to the communication device based on strengths of received signals at the communication device from different receive paths. The orientation information is a change in three-dimensional orientation of the communication device. The altering means include a beam-forming module and the antenna module includes a phased-array antenna including antenna elements and a phase module configured to set phases for corresponding ones of the antenna elements to point the directional beam in a desired direction. The altering means include a beam-steering module configured to redirect the directional beam provided by the antenna module. The altering means are further for adjusting a width of the directional beam in response to movement of the device indicated by the orientation means.

An example of a computer program product resides on a non-transitory processor-readable medium and includes processor-readable instructions configured to cause a processor to: obtain three-dimensional orientation information for the wireless communication device indicative of a three-dimensional orientation of a wireless communication device; determine, based on the orientation information, a desired change in three-dimensional direction of a directional beam provided by an antenna module of the wireless communication device in order to compensate for a change in three-dimensional orientation of the wireless communication device; and cause the antenna module to change a three-dimensional direction that the directional beam is pointing based on the determined desired change in three-dimensional direction of the directional beam.

Implementations of such a computer program product may include one or more of the following features. The orientation information is present orientation information indicative of a present orientation of the wireless communication device and the instructions configured to cause the processor to determine the desired change are configured to cause the processor to analyze a previous orientation of the wireless communication device indicated by previous orientation information and the present orientation of the wireless communication device indicated by the present orientation information to determine a change in orientation of the wireless communication device. The instructions configured to cause the processor to determine the desired change are configured to cause the processor to account for available directions of the directional beam achievable by the antenna module of the wireless communication device.

Additionally or alternatively, implementations of the computer program product may include one or more of the following features. The computer program product further includes instructions configured to cause the processor to: obtain a location of the wireless communication device; obtain a location of the base transceiver station; and determine a direction from the wireless communication device toward the base transceiver station using the location of the device, the location of the base transceiver station, and the orientation of the communication device. The instructions configured to cause the processor to obtain the location of the wireless communication device are configured to cause the processor to analyze satellite positioning system signals to obtain the location of the wireless communication device.

Additionally or alternatively, implementations of the computer program product may include one or more of the following features. The orientation information is indicative of a change in three-dimensional orientation of the wireless communication device, the instructions further include instructions configured to cause the processor to obtain a location of the wireless communication device, and the instructions configured to cause the processor to determine the desired change are configured to cause the processor to use the location of the wireless communication device in addition to the three-dimensional orientation information. The computer program product further includes instructions configured to cause the processor to determine a direction from the wireless communication device toward a base transceiver station based on strengths of received signals at the wireless communication device from the base transceiver station over different receive paths. The instructions configured to cause the processor to cause the antenna module to change a three-dimensional direction that the directional beam is pointing are configured to cause the processor cause a change in phase of at least one radiating element of a phased-array antenna of the antenna module. The instructions configured to cause the processor to cause the antenna module to change a three-dimensional direction that the directional beam is pointing are configured to cause a beam steering of the directional beam provided by the antenna module.

An example of a method of affecting a direction of a mobile wireless communication device antenna includes: obtaining a first direction of a base transceiver station relative to the mobile wireless communication device; obtaining a three-dimensional orientation of the mobile wireless communication device from at least one orientation sensor of the mobile wireless communication device; determining a second direction of the base transceiver station relative to the three-dimensional orientation of the mobile wireless communication device based upon the first direction and the three-dimensional orientation of the mobile wireless communication device; and setting a three-dimensional beam direction of an antenna beam of an antenna of the mobile wireless communication device according to the second direction.

Implementations of such a computer program product may include one or more of the following features. Obtaining the orientation of the mobile wireless communication device includes obtaining a change in the orientation of the mobile wireless communication device and setting the beam direction includes causing a change in a present beam direction according to the change in the orientation. Obtaining the orientation includes at least one of (1) obtaining three-dimensional gyroscope information or (2) obtaining three-dimensional compass information and gravity direction information. Obtaining the first direction includes at least one of (1) obtaining a location of the mobile wireless communication device using satellite positioning system signals or (2) analyzing strengths of signals received by the mobile wireless communication device from the base transceiver station. Setting the beam direction includes beam-forming the antenna beam. The Setting the beam direction includes beam-steering the antenna beam.

Another example of a mobile wireless communication device includes: an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing communication signals for reception by a base transceiver station and to receive electromagnetic energy of incoming signals from the base transceiver station; determining means for determining at least one of a measure of signal quality of signals received by the antenna module or a measure of motion of the device, and for providing at least one of an indication corresponding to the signal quality or an indication of the motion exceeding a motion threshold; and altering means, communicatively coupled to the antenna module and the determining means, for causing the antenna module to widen a main beam of the antenna pattern in response to at least one of the indication of signal quality or the indication of the motion exceeding the motion threshold.

Implementations of such a device may include one or more of the following features. The altering means are configured to widen the main beam in response to the signal quality declining. The altering means are configured to widen the main beam in response to a relative power of the received signals dropping below a relative power threshold. The altering means are configured to widen the main beam to a first width in response to the indication of signal quality and to a second width in response to the indication of the motion exceeding the motion threshold, the second width being larger than the first width. The altering means are configured to cause the antenna module to increase power provided by the antenna module for the main beam concurrently with widening the main beam. The altering means are further for causing the antenna module to narrow the main beam of the antenna pattern in the absence of the indication of signal quality and the indication of the motion exceeding the motion threshold. The altering means are configured to cause the antenna module to decrease power provided by the antenna module for the main beam concurrently with narrowing the main beam. The indication of signal quality is at least one of an indication of signal-to-noise ratio of a received signal or a command to widen the main beam. The sensing means are for providing a measure of three-dimensional motion of the device.

Items and/or techniques described herein may provide one or more of the following capabilities, as well as other capabilities not mentioned. The effects of noise and/interference on wireless data communications can be reduced. Data throughput for wireless communications can be increased. Power consumption for wireless communications can be decreased. Beam forming and/or steering can be used at a mobile device to help reduce effects of noise and interference in wireless communications. Beam forming and/or steering can be employed in devices whose orientation changes very rapidly. Beam forming and/or steering at a mobile device can be accomplished in one or two dimensions. While at least one item/technique-effect pair has been described, it may be possible for a noted effect to be achieved by means other than that noted, and a noted item/technique may not necessarily yield the noted effect.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a wireless telecommunication system.

FIG. **2** is a block diagram of components of a mobile station shown in FIG. **1**.

FIG. **3** is a combined block and functional-block diagram of the mobile station shown in FIG. **2**.

FIG. **4** is a block flow diagram of a process of determining a desired antenna direction from a mobile station and updating the antenna direction with changes in orientation of the mobile device.

FIG. **5** is an alternative combination block and functional-block diagram of a system for directing and redirecting an antenna beam based on orientation of a mobile device.

FIG. **6** is a block flow diagram of an alternative process of determining a desired antenna direction from a mobile station and updating the antenna direction with changes in orientation of the mobile device.

FIG. **7** is a block flow diagram of a process of determining a desired antenna direction from a mobile station, updating the antenna direction with changes in orientation of the mobile device, and selectively altering a width of an antenna beam.

## DETAILED DESCRIPTION

Techniques are described herein for determining and adjusting a desired beam direction used by a mobile device for wireless communications. For example, a mobile device such as a phone can determine a direction from the mobile phone to a local base transceiver station (BTS). The mobile phone can monitor orientation sensors to determine changes in orientation of the mobile phone and thus changes in direction of the BTS from the initial detection of the desired antenna direction. The orientation sensors can be further monitored for determining changes in the orientation from the most-recent orientation determination. Using the changes in orientation, the mobile phone can change the direction of a main beam associated with one or more antennas of the mobile phone so that the main beam is directed toward the BTS. For example, the orientation can be determined using a three dimensional gyroscope and/or a three dimensional compass plus information as to the direction of gravity relative to the mobile phone. Further, location of the mobile device can be monitored, e.g., through use of global positioning system (GPS) or other satellite positioning system (SPS) information (e.g., GLONASS information). The location information can be used in determining the direction of the BTS relative to mobile device. These techniques are examples only and are not limiting of the disclosure or the claims. For example, while the description focuses on cellular phone technology, the techniques described have other applications such as high-frequency communications such as 60 GHz communications systems, or even light-based communications, e.g., infrared systems or laser systems.

Referring to FIG. **1**, a wireless communication system **10** includes mobile access terminals **12** (ATs), base transceiver stations (BTSs) **14** disposed in cells **16**, and a base station controller (BSC) **18**. The system **10** may support operation on multiple carriers (waveform signals of different frequencies). The system **10** is a communication system in that the system **10** can at least send or receive communications although it need not be, but preferably is, able to send and receive communications. Multi-carrier transmitters can transmit modulated signals simultaneously on the multiple carriers. Each modulated signal may be a CDMA signal, a TDMA signal, an

OFDMA signal, a SC-FDMA signal, etc. Each modulated signal may be sent on a different carrier and may carry pilot, overhead information, data, etc.

The BTSs **14** can wirelessly communicate with the terminals **12** via antennas. Each of the BTSs **14** may also be referred to as an access point, an access node (AN), a Node B, an evolved Node B (eNB), etc. The BTSs **14** are configured to communicate with the ATs **12** under the control of the BSC **18** via multiple carriers. Each of the base stations **14** can provide communication coverage for a respective geographic area, here the respective cells **16**. Each of the cells **16** of the base stations **14** is partitioned into multiple sectors as a function of the base station antennas.

The system **10** may include only macro base stations **14** or it can have base stations **14** of different types, e.g., macro, pico, and/or femto base stations. A macro base station may cover a relatively large geographic area (e.g., several kilometers in radius) and may allow unrestricted access by terminals with service subscription. A pico base station may cover a relatively small geographic area (e.g., a pico cell) and may allow unrestricted access by terminals with service subscription. A femto or home base station may cover a relatively small geographic area (e.g., a femto cell) and may allow restricted access by terminals having association with the femto cell (e.g., terminals for users in a home).

The ATs **12** can be dispersed throughout the cells **16**. The ATs **12** may be referred to as mobile stations, mobile devices, user equipment (UE), or subscriber units. The ATs **12** here include cellular phones and a wireless router, but can also include personal digital assistants (PDAs), other handheld devices, netbooks, notebook computers, etc.

Referring also to FIG. **2**, an exemplary one of the ATs **12** comprises a computer system including a processor **20**, memory **22** including software **24**, a display **26**, antennas **28**, a satellite positioning system module, here a Global Positioning System (GPS) module **30**, and orientation sensors **32**. The antennas **28** include a transceiver configured to communicate bi-directionally with the BTSs **14** via the antennas **28**. The processor **20** is preferably an intelligent hardware device, e.g., a central processing unit (CPU) such as those made by ARM®, Intel® Corporation, or AMD®, a microcontroller, an application specific integrated circuit (ASIC), etc. The processor **20** could comprise multiple separate physical entities that can be distributed in the AT **12**. The memory **22** includes random access memory (RAM) and read-only memory (ROM). The memory **22** stores the software **24** which is computer-readable, computer-executable software code containing instructions that are configured to, when executed, cause the processor **20** to perform various functions described herein. Alternatively, the software **24** may not be directly executable by the processor **20** but is configured to cause the computer, e.g., when compiled and executed, to perform the functions.

In this example, the mobile device **12** as configured to use beam forming to direct an antenna beam. The mobile device **12** here includes three antennas **28** (although other quantities of antennas could be used) as part of an antenna module and the antennas **28** further include corresponding phase shifters **29**. Each of the antennas **28** preferably has its own dedicated phase shifter **29**. The phase shifters **29** are connected to the processor **20** and can respond to commands from the processor **20** to affect the phase of signals provided to the antennas **28** for transmission to the BTS **14**.

The GPS module **30** includes appropriate equipment for monitoring GPS signals from satellites and determining position of the mobile device **12**. For example, the GPS module **30** includes one or more GPS antennas, and can either communicate with the processor **20** to determine location information or can use its own processor for processing the received GPS signals to determine the location of the mobile device **12**. Further, the GPS module **30** can communicate with other entities such as a position determination entity and/or the BTS **14** in order to send and/or receive assistance information for use in determining the location of the mobile device **12**.

The orientation sensors **32** are configured to determine an initial orientation of the mobile device **12** and to provide information as to changes in the orientation of the mobile device **12**. Referring also to FIG. **3**, the orientation sensors **32** include a three-dimensional gyroscope **40**, an accelerometer **42**, and a three-dimensional compass **44**. The orientation sensors **32** are configured to provide information from which the orientation of the mobile device **12** can be determined. The sensors **32** can provide information over time (e.g., periodically, in response to an event such as a change in position or orientation, etc.) such that present and past positions and/or orientations can be compared to determine changes in the position and/or orientation of the mobile device **12**. The gyroscope **40** can provide information as to motion of the mobile device **12** affecting the orientation. The accelerometer **42** is configured to provide information as to gravitational acceleration such that the direction of gravity relative to the mobile device **12** can be determined as well as changes in speed (e.g., a vehicle starting to move, speed up, slow down, make a turn, etc.). The three-dimensional compass **44** is configured to provide an indication of the direction, in three dimensions, of magnetic north relative to the mobile device **12**, e.g., to a coordinate system of the mobile device **12**.

The mobile device **12** shown in FIG. **2** includes the gyroscope **40**, the accelerometer **42**, the compass **44**, and the GPS module **30**. Other examples of mobile devices, however, may not include all of these components **40**, **42**, **44**, **30**. For example, a mobile device may include the three-dimensional gyroscope **40** only. Alternatively, a mobile device may include the accelerometer **42** and the three-dimensional compass **44** only. Alternatively still, a mobile device having either the gyroscope **40** or the accelerometer **42** and the compass **44** may include the GPS module **30**. Still other examples/configurations are possible and the examples provided are not a complete or exhaustive list of possibilities.

Information from the sensors **40**, **42**, **44**, **30** is provided to a sensor module **46** with sensor algorithms. The sensor algorithms **46** are implemented by the processor **20** in conjunction with the software **24** stored in the memory **22**. These algorithms, as executed by the processor **20**, are configured to process the information from the sensors **40**, **42**, **44**, **30** to determine changes in the direction of the BTS **14** relative to a previous position and orientation of the mobile device **12** (e.g., the initial orientation, a most-recent prior orientation, or a different reference orientation). Thus, preferably six dimensions of information are determined, a three-dimensional change in position and a three-dimensional change in orientation, resulting in a three-dimensional change in antenna beam direction relative to the mobile device **12**. The algorithms **46** use information as to changes in the orientation relative to gravity as well as changes in position of the mobile device **12** relative to the earth in order to assist in determining the present direction of the BTS **14** relative to the coordinate system of the mobile device **12**. For example, the algorithms **46** can determine the initial position of the mobile device **12** relative to the BTS **14**, determine the orientation of the mobile device **12** relative to gravity, and determine a desired direction of an antenna beam from the mobile device **12** to the BTS **14**. Further, using information as to changes in the position and/or orientation of the mobile device **12**, the algorithms **46** can determine changes in the desired antenna beam direction relative to the coordinate system of the mobile device **12** in order to have the antenna beam point toward the BTS **14**. The beam need not point directly at the BTS **14** (i.e., line-of-sight between the mobile device **12** and the BTS **14** is not required), but preferably points toward the BTS **14** enough so that a desired amount of gain is provided in the direction of the BTS **14** to provide good/desired signal channel characteristics (e.g., quality, power, signal-to-noise ratio (SNR), signal-to-noise-and-interference ratio (SINR), etc.).

Information determined from the sensor algorithms **46** as to the initial orientation of the mobile device relative to the BTS **14** and/or changes in the orientation of the mobile device **12** relative to the desired BTS **14** are provided to an antenna direction (and width) controller **48**. The controller **48** can affect the beam width of the main beam as discussed further below with respect to FIG. **7**. The antenna direction controller **48** is also implemented by the processor **20** executing appropriate software **24** stored in the memory **22**. The antenna direction controller **48** determines adjustments to be made in order to direct or redirect the main antenna beam from the mobile device **12** toward the desired BTS **14**. The controller **48** determines these adjustments based on the changes in orientation of the mobile device **12**, especially changes in the orientation of the mobile device **12** relative to the desired BTS **14** determined by the sensor algorithms **46**. To implement the adjustments, the antenna direction controller **48** determines phase shifts to be implemented by the phase shifters **29** for the respective antennas **28** to electronically form or direct the main beam of the antennas **28** toward the desired BTS **14**.

The antenna direction and beam width controller **48** provides information for forming the main beam of the antennas **28** to a beam-altering module/beam former **50**. The antenna pattern including the main beam can be formed and used for transmitting or receiving information, providing highest gain to/from a desired direction and lesser gain to/from undesired directions. Here, the beam former **50** comprises the phase shifters **29** and amplifiers **31** for electronically altering the excitation signals provided to the antennas **28**. The relative phases of the signals provided to the antennas **28** via the phase shifters **29** will cause the main beam of the antennas **28** to point in a desired direction. As shown, the antennas **28** receive signals from the beam former **50** and are excited by the signals, inducing an antenna pattern **52** with a main beam **54** directed in accordance with the phases of signals provided by the beam former **50**. The phases provided by the beam former **50** of the excitation signals for the antennas **28**, combined with a layout of the antennas **28**, result in the main beam **54** being directed in a desired direction. Here, in this example with three antennas **28** in a line, the main beam **54** can be directed/redirected in one dimension while, if antennas are disposed in a 2-dimensional array, then the main beam **54** could be directed/redirected in two dimensions.

The mobile device **12** also includes a fine-search module **49**. The module **49** is in parallel with the sensors **30**, **40**, **42**, **44**, and is configured to monitor the quality of signals received through the antennas **28**. The signals from the antennas **28** may be sensed or measured directly or indirectly (e.g., by monitoring signals in receive circuitry or output from this circuitry), e.g., by the processor **20** analyzing received signals, to determine a measure of the signal quality (e.g., power). The module **49** tracks the signal quality to determine if the direction of the BTS **14** is moving away from the peak of the main beam toward a null in the antenna pattern. The module **49** can respond to sensing that the quality (e.g., as indicated by received power level) is dropping or has dropped undesirably (e.g., greater than a relative amount such as 3 dB) by providing an indication to the controller **48**. This indication can be an indication that the signal quality is dropping or that the signal quality is below a desired quality, or can be an indication/command to widen the main beam **54**. The module **49** could also indicate to narrow the beam **54** and/or decrease the power, or the controller **48** could determine to narrow the beam **54** and/or decrease the power, e.g., if signal quality is good, e.g., for longer than a signal quality threshold time, and/or if device motion is lower than a threshold, e.g., for longer than a movement threshold time.

The antenna direction controller **48** is also configured to provide information for forming the main beam **54** of the antennas **28** to the beam former **50** to produce a desired width of the main beam **54**. The controller **48** provides indications of phase and amplitude to be implemented by the phase shifters **29** and the amplifiers **31** for the signals provided to the antennas **28** to produce the beam **54** with the desired width. The desired width can be determined by the controller **48** in a variety of ways. For example, the width can be increased in response to the indication from the fine-search module **49** that the signal quality has decreased, or in response to a command from the module **49** to widen the beam **54**. The width of the beam **54** can be reduced periodically in the absence of the indication/command from the module **49**, and with any change in orientation of the device **12** being less than a threshold amount of change, or being less than the change threshold for more than a threshold time. A reduction in beam width, implemented by the controller **48**, could be linear (e.g., a fixed number of degrees each time the width is adjusted) or non-linear (e.g., increasing amounts of degrees smaller each time the width is adjusted). As another example, the width can be set to a desired width as a function of the amount of change in beam direction (e.g., directly proportional to the change, set to one of a N widths depending on the amount of change being within one of N ranges of change, etc.). The available widths of the beam **54** depends, e.g., upon the number of antennas **28**, the arrangement of the antennas **28**, the available variation of the phase shifters **29** and/or the amplifiers **31**, etc.

The controller **48** can affect the amount of power used by the amplifiers **31** and thus provided in the beam **54**. Preferably, the power would vary in relation to the beam width, in an inverse fashion. For wider beam widths, the controller **48** can cause the amplifiers **31** to use more power cumulatively, and for narrower beam widths, the controller **48** can cause the amplifiers **31** to use less power cumulatively (i.e., for the amplifiers **31** combined). The variation could be linear, stepped (e.g., one of several discrete power levels for each of several corresponding beam width ranges, etc.).

Referring to FIG. **4**, with further reference to FIGS. **1-3**, a process **110** of directing an antenna direction based on orientation sensor measurements includes the stages shown. The process **110** is, however, an example only and not limiting. The process **110** can be altered, e.g., by having stages added, removed, rearranged, combined, and/or performed concurrently.

At stage **112**, the position of the mobile device **12** is determined. The GPS module **30** determines the location of the mobile device **12** relative to the earth. The GPS module **30** may communicate with other entities such as a position determining entity in order to determine the position of the mobile device **12**.

At stage **114**, the mobile device **12** determines the direction from the mobile device **12** to a desired BTS **14**. For example, the processor **20** can analyze strengths of signals received by the antennas **28**. The processor **20** can determine a direction of greatest signal strength from one of the BTSs **14** as the direction toward a desired BTS **14**. Alternatively, the processor **20** can communicate with the GPS module **30** to determine the location of the mobile device **12** relative to the earth and to communicate with the memory **22** to determine locations of local BTSs **14**. The processor **20** can select one of the local BTSs **14**, e.g., the closest BTS **14**, the BTS **14** most likely to have a direct line of sight to the mobile device **12**, etc., and determine the desired direction from the mobile device **12** to the desired BTS **14** using mathematical calculations. The processor **20** further determines the orientation of the mobile device **12**, using information provided by the orientation sensors **32**. The processor **20** combines the orientation information with the mobile device-to-BTS direction to determine the three-dimensional direction of the BTS **14** relative to the mobile device **12**.

At stage **116**, the processor **20** determines changes in the orientation of the mobile device **12**. The processor **20** continues to determine the orientation of the mobile device **12** by applying the sensor algorithms **46** to the available sensor information from the gyroscope **40**, the accelerometer **42**, and the compass **44**. The processor **20** stores the orientation information and determines a difference between the present orientation of the mobile device **12** with a previous orientation of the mobile device **12** to determine the change in the orientation. The previous orientation can be any previous orientation such as an initial orientation, a most-recent orientation, etc.

At state **118**, the processor **20** determines a desired change in the beam direction corresponding to the change in the orientation of the mobile device **12**. The processor **20** uses the change in orientation of the mobile device **12** to determine desired changes in the beam direction in order to have the main beam **54** point toward the desired BTS **14**.

At stage **120**, the processor **20** uses the desired change in beam direction determined at stage **118** to determine parameters to affect the desired change in direction of the main beam **54**. Here, the processor **20** determines phase values (either phase amount changes or desired amount of phase) for the phase shifters **29** in order to direct the main beam **54** as desired.

At stage **122**, the determined phase values are provided to the phase shifters **29** to change the, preferably three-dimensional, direction of the main beam **54**. The phase shifters **29** alter the amount of phase shift induced by the phase shifters **29**, thereby affecting the incoming signals by the corresponding phase amounts, which are then provided to the antennas **28**. The main beam **54** induced by the signals received by the antennas **28** is then directed, preferably in three dimensions, in accordance with the phases of the signals from the phase shifters **29**.

At stage **124**, an inquiry is made as to whether a counter has reached a threshold. If the counter has not reached the threshold, then at stage **126**, the counter is incremented and the process **110** returns to stage **116** where the change in orientation of the mobile device **12** is determined. If, however, the counter has reached the threshold, then at stage **128**, the counter is reset to **1** and the process **110** returns to stage **112** where the location of the mobile device **12** is determined using the GPS module **30**. In this way, the location of the mobile device is periodically determined, less frequently than the orientation change is determined, to update the desired direction of the main beam **54** for the desired BTS **14**. This can help refine the direction of the main beam **54** while allowing speedier processing most often by using information from the orientation sensors **40**, **42**, **44** without using location information from the GPS module **30** Alternatively, stages **124**, **126**, **128**, can be omitted from the process **110** such that the location of the mobile device **12** as determined by the GPS module **30** is used each time in determining changes in orientation of the mobile device **12**, at least the orientation of the main beam **54** relative to the desired BTS **14**.

Other techniques may be employed for directing the main beam **54**, or another main beam, toward a particular BTS **14**. For example, referring to FIG. **5**, instead of the mobile device **12** including the beam former **50** and three antennas **28**, as shown in FIG. **3**, a different mobile device **12** includes a beam steering module **60** and an antenna system **58**. The module **60** may be particularly useful for infrared and laser applications. Various configurations of the antenna system **58** and the beam steering module **60** are possible. For example, the antenna system **58** may include multiple antennas with main beams directed at fixed, different orientations relative to the mobile device **12**. The beam steering module **60** would be configured to use the information from the antenna direction controller **48** in order to select the most appropriate antenna from the antenna system **58** to provide a main beam directed most closely to the desired BTS **14**. As another example, the antenna system **58** may comprise one or more antennas with fixed phase providing a stationary main beam **54** and the beam steering module **60** is configured to move the direction of the beam produced by the antenna system **58**. For example, the beam steering module **60** could comprise a reflector that is mechanically moved to reflect the beam provided by the antenna system **58** to different directions. Alternatively, the beam steering module **60** could provide a transparent lens with changing optical characteristics such as a changing refraction index in order to direct the stationary beam from the antenna system **58** to a desired direction. Alternatively still, the antenna system **58** could provide a stationary beam relative to one or more antennas and the beam steering module **60** could comprise a mechanical gimbal on which the antenna system **58** rests. The beam steering module **60** would move the physical orientation of the antenna system **58** to a desired direction to point the main beam toward the desired BTS **14**. Alternatively, the module **60** could employ micro electro-mechanical systems (MEMS) technology.

Further, referring to FIG. **6**, with further reference to FIGS. **1-3**, an alternative process **150** of directing an antenna direction based on orientation sensor measurements includes the stages shown. The process **150** is, however, an example only and not limiting. The process **150** can be altered, e.g., by having stages added, removed, rearranged, combined, and/or performed concurrently. Using the process **150**, AT position can be re-determined if the AT **12** moves more than a threshold amount. The position can be re-determined using either accelerometer information or GPS information depending on the magnitude of the movement. Further, AT position can be re-determined using accelerometer information periodically, and using GPS information periodically, but less often than using accelerometer information.

At stage **152**, the position of the mobile device **12** is determined. In this stage, either the GPS module **30** or the processor **20** in combination with the accelerometer **42** determines the location of the mobile device **12** relative to the earth. Accelerometer information is used after the first time through the process **150** if AT movement greater than a first threshold, but lower than a second threshold is detected, or if a value of a predetermined constant is a multiple of a counter value and the counter value is less than a count threshold. GPS information is used to determine AT position the first time through the process **150**, if AT movement is greater than a second movement threshold, or when the counter reaches the count threshold.

Stages **114**, **116**, **118**, **120**, and **122** of the process **150** are similar to these stages of the process **110** described above.

At stage **154**, a determination is made as to whether the AT **12** has moved more than a threshold amount. The processor **20** uses information from the accelerometer **42** to determine whether the AT has moved more than a first, lower movement threshold amount. If the AT has moved more than the first threshold, then the process **150** returns to stage **152** where the position of the AT **12** is determined. The position is determined using the accelerometer output and the most recent GPS position if the movement is less than a second, higher movement threshold that is greater than the first, lower movement threshold. The position is determined using the GPS module **30** if the movement is greater than the second movement threshold amount. If at stage **154** the processor **20** determines that the movement of the AT **12** is not greater than the first movement threshold amount, then the process **150** proceeds to stage **124**.

At stage **124**, an inquiry is made as to whether counter has reached a threshold. If the counter has not reached the threshold, then at stage **126**, the counter is incremented and the process **150** proceeds to stage **156** where the processor **20** determines whether a remainder of a quotient of a constant, A, divided by the counter value N is zero. If so, then the process returns to stage **152** where the position of the AT **12** is determined using accelerometer information. Otherwise, the process **150** returns to stage **116** where the change in orientation of the mobile device **12** is determined. If, however, at stage **124** the counter has reached the threshold, then at stage **128**, the counter is reset to **1** and the process **150** returns to stage **152** where the location of the mobile device **12** is determined using the GPS module **30**. In this way, the location of the mobile device is periodically determined using accelerometer information more often than the position is periodically determined using GPS information, and is determined less frequently than the orientation change is determined.

Further, referring to FIG. **7**, with further reference to FIGS. **1-3**, a process **160** of directing and selectively focusing an antenna beam based on orientation sensor measurements includes the stages shown. The process **160** is, however, an example only and not limiting. The process **160** can be altered, e.g., by having stages added, removed, rearranged, combined, and/or performed concurrently. Using the process **160**, the antenna beam's width (e.g., 3 dB width) can be adjusted based on a confidence of the direction of the BTS **14** and motion of the AT **12** (i.e., implied confidence of the beam direction).

Stages **152**, **154**, **156**, **114**, **116**, **118**, **120**, **122**, **124**, **126**, and **128** of the process **160** are similar to these stages of the process **150** described above.

At stage **162**, a determination is made as to a confidence level of the direction of the BTS **14** relative to the AT **12**, and the beam width adjusted as appropriate. For example, the processor **20** determines whether the beam direction change determined in stage **118** satisfies one or more criteria, e.g., is less than a threshold change, is less than the threshold change for longer than a threshold time (or for a threshold number of increments of the counter), etc. If the change satisfies the one or more criteria, then the antenna direction controller **48** determines adjustments, if any, to be made in order to focus the main antenna beam from the mobile device **12** as desired (i.e., to leave the focus alone, to narrow the main beam width, or to broaden the main beam width). To implement the adjustments, the antenna direction and width controller **48** determines phase shifts and signal amplitudes to be provided by the phase shifters **29** and amplifiers **31** for the respective antennas **28** to electronically form the main beam of the antennas **28** with a desired main beam width.

The desired width can be determined or set in a variety of ways. For example, the width can be reduced (narrowed), e.g., each time stage **162** occurs, with the change in beam direction being less than a threshold amount of change, or each time only after the change in beam direction is less than the change threshold for more than a threshold number of consecutive times through the process **160**. Further, the width can be reduced less often than each time through the process **160**. The main beam of the antenna pattern can be narrowed in response to termination of an indication of signal quality being poor or termination of an indication of motion exceeding a motion threshold. The reduction could be linear (e.g., a fixed number of degrees each time the width is adjusted), non-linear (e.g., increasing amounts of degrees smaller each time the width is adjusted), or set to a discrete level, etc. As another example, the width can be set to a desired width as a function of the amount of change in beam direction (e.g., directly proportional to the change, set to one of a N widths depending on the amount of change being within one of N ranges of change, etc.). The width will have a lower and an upper limit, e.g., depending upon the number of antennas **28**, the arrangement of the antennas **28**, the available variation of the phase shifters **29** and/or the amplifiers **31**, etc.

At stage **164**, a determination is made as to whether the signal quality received by the AT **12** has dropped more than a fine-search threshold amount. The fine-search module **49** monitors the received signal quality. If the fine-search module **49** determines that the signal quality has dropped undesirably, then the process **160** proceeds to stage **166**, and otherwise proceeds to stage **154**.

At stage **166**, the width of the main beam **54** is adjusted as appropriate. The fine-search module **49** responds to the signal quality dropping undesirably by providing an indication or command to the controller **48**. The controller **48** responds to the indication or command by providing appropriate information or commands to the beam former **50** to adjust the phase shifters **29** and amplifiers **31** to widen the width of the beam **54** (e.g., in any manner discussed above, or in any other desired manner) and to increase the power in the beam **54** to compensate for the direction change of the device **12** implied by the reduction in signal quality. The process **160** proceeds to stage **154**.

At stage **168**, with the AT movement determined at stage **154** to exceed a movement threshold, the beam width is adjusted, e.g., reset or widened. The movement threshold, e.g., a macro-movement threshold, used in stage **154** is larger than the direction change implied by the reduction of signal quality corresponding to the fine-search threshold. Thus, the controller **48** will typically, though not necessarily, widen the beam by more, or to a larger width, at stage **168** than at stage **164**. With movement exceeding the macro-movement threshold, the direction and width of the beam **54** may not be adequate for acceptable communication with the BTS **14**. The controller **48** causes the beam former **50** to adjust the width of the beam **54** as appropriate. Preferably, the controller **48** causes the beam former **50** to reset the width of the beam **54** to a default, large width to help the AT **12** remain in communication with the BTS **14**. Alternatively, the adjustment may not be to reset the beam width to a default width, but rather to increase the beam width. The increase in width could be a fixed amount, or the amount could be dependent upon the amount of movement (e.g., magnitude of movement, relative magnitude of movement compared to the threshold, etc.). Further, while FIG. **7** shows that the same movement threshold is used to trigger a beam width adjustment at stage **164** and to cause the process **160** to return to stage **152**, different movement thresholds could be used, e.g., with a smaller threshold triggering beam width adjustment than triggering a redetermination of mobile device position.

Still other examples and techniques are possible. For example, while the description discussed a counter being compared against a threshold at stage **124**, other techniques could be used. For example, a timer could be used as a trigger for determining location of a mobile device. Alternatively still, an accelerometer could be used as a trigger, such as by integrating an output of the accelerometer to determine speed and using the speed to determine whether and how often to determine location. The frequency of location determination could be proportional, or roughly proportional, to the speed. For example, if the speed is zero or below a small threshold, then there may be no location determination or very infrequent location determination. If, however, the speed is high (e.g., the mobile device is on a train), then the location could be determined more often, e.g., proportional to the speed, or at frequencies corresponding to ranges of speed, or combinations of these techniques. Further still, Doppler information could be determined/collected and used as an indication of the speed and location determination frequency based upon the Doppler information.

As used herein, including in the claims, "or" as used in a list of items prefaced by "at least one of" indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C" means A or B or C or AB or AC or BC or ABC (i.e., A and B and C), or combinations with more than one feature (e.g., AA, AAB, ABBC, etc.). Further, a wireless communication network does not have all communications transmitted wirelessly, but is configured to have at least some communications transmitted wirelessly.

A mobile wireless communication device may comprise: an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing communication signals for reception by a base transceiver station and to receive electromagnetic energy of incoming signals from the base transceiver station; a motion sensor; and a processor communicatively coupled to the antenna module and the motion sensor and configured to: determine at least one of a measure of signal quality of signals received by the antenna module or a measure of motion of the device; provide at least one of an indication corresponding to the signal quality or an indication of the motion exceeding a motion threshold; and cause the antenna module to widen a main beam of the antenna pattern in response to at least one of the indication of signal quality or the indication of the motion exceeding the motion threshold.

This device may include one or more of the following features. The processor is configured to cause the antenna module to widen the main beam in response to the signal quality declining. The processor is configured to cause the antenna module to widen the main beam in response to a relative power of the received signals dropping below a relative power threshold. The processor is configured to cause the antenna module to widen the main beam to a first width in response to the indication of signal quality and to a second width in response to the indication of the motion exceeding the motion threshold, the second width being larger than the first width. The processor is configured to cause the antenna module to increase power provided by the antenna module for the main beam concurrently with widening the main beam. The processor is configured to cause the antenna module to narrow the main beam of the antenna pattern in the absence of the indication of signal quality and the indication of the motion exceeding the motion threshold. The processor is configured to cause the antenna module to decrease power provided by the antenna module for the main beam concurrently with narrowing the main beam. The indication of signal quality is at least one of an indication of signal-to-noise ratio of a received signal or a command to widen the main beam. The motion sensor is configured to provide a measure of three-dimensional motion of the device.

A computer program product may reside on a non-transitory processor-readable medium of a mobile wireless communication device that includes an antenna module and a motion sensor, with the computer program product comprising processor-readable instructions configured to cause a processor to: determine at least one of a measure of signal quality of signals received by an antenna module or a measure of motion of the device; provide at least one of an indication corresponding to the signal quality or an indication of the motion exceeding a motion threshold; and cause the antenna module to widen a main beam of the antenna pattern in response to at least one of the indication of signal quality or the indication of the motion exceeding the motion threshold.

This computer program product may include one or more of the following features. The instructions are configured to cause the processor to cause the antenna module to widen the main beam in response to the signal quality declining The instructions are configured to cause the processor to cause the antenna module to widen the main beam in response to a relative power of the received signals dropping below a relative power threshold. The instructions are configured to cause the processor to cause the antenna module to widen the main beam to a first width in response to the indication of signal quality and to a second width in response to the indication of the motion exceeding the motion threshold, the second width being larger than the first width. The instructions are configured to cause the processor to cause the antenna module to increase power provided by the antenna module for the main beam concurrently with widening the main beam. The instructions are configured to cause the processor to cause the antenna module to narrow the main beam of the antenna pattern in the absence of the indication of signal quality and the indication of the motion exceeding the motion threshold. The instructions are configured to cause the processor to cause the antenna module to decrease power provided by the antenna module for the main beam concurrently with narrowing the main beam. The indication of signal quality is at least one of an indication of signal-to-noise ratio of a received signal or a command to widen the main beam.

A method in a mobile wireless communication device may comprise: transmitting electromagnetic energy of outgoing communication signals, configured for reception by a base transceiver station, using an antenna pattern having a directional beam; receiving electromagnetic energy of incoming signals from the base transceiver station; determining at least one of a measure of signal quality of signals received by the antenna module or a measure of motion of the device; providing at least one of an indication corresponding to the signal quality or an indication of the motion exceeding a motion threshold; and widening a main beam of the antenna pattern in response to at least one of the indication of signal quality or the indication of the motion exceeding the motion threshold.

This method include one or more of the following features. Widening the main beam is in response to the signal quality declining. Widening the main beam in response to a relative power of the received signals dropping below a relative power threshold. The widening comprises widening the main beam to a first width in response to the indication of signal quality and to a second width in response to the indication of the motion exceeding the motion threshold, the second width being larger than the first width. The method may further comprise increasing power provided of the main beam concurrently with widening the main beam. The method may further comprise narrowing the main beam of the antenna pattern in response to termination of the indication of signal quality or termination of the indication of the motion exceeding the motion threshold. The method may further comprise decreasing power of the main beam concurrently with narrowing the main beam. The indication of signal quality is at least one of an indication of signal-to-noise ratio of a received signal or a command to widen the main beam. The determining comprises determining a measure of three-dimensional motion of the device.

Still other techniques and implementations are possible.

What is claimed is:

**1**. A mobile wireless communication device comprising:

a communication device housing;

an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing signals and to receive electromagnetic energy of incoming signals;

a beam-altering module communicatively coupled to the antenna module and configured to alter a three-dimensional direction that the directional beam is pointing; and

a three-dimensional orientation sensor module communicatively coupled to the beam-altering module and configured to obtain three-dimensional orientation information for the communication device, the three-dimensional orientation information indicative of a three-dimensional orientation of the wireless communication device;

wherein the beam-altering module is configured to determine, based on the three-dimensional orientation information, a desired change in three-dimensional direction of the directional beam in order to compensate for a change in three-dimensional orientation of the wireless communication device; and

wherein the antenna module is configured to change the three-dimensional direction that the directional beam is pointing based on the determined desired change in three-dimensional direction of the directional beam.

**2**. The device of claim **1** wherein the beam-altering module is configured to determine a direction from the wireless communication device toward a base transceiver station.

**3**. The device of claim **2**, the wireless communication device further comprising a satellite positioning system module configured to determine a location of the wireless communication device, and wherein the beam-altering module being configured to determine a location of the base transceiver station and being configured to determine the direction from the wireless communication device toward the base transceiver station using the location of the wireless communication device, the location of the base transceiver station, and the orientation of the wireless communication device.

**4**. The device of claim **2**, the wireless communication device further comprising a satellite positioning system module configured to determine a location of the wireless communication device, and wherein the beam-altering module is configured to use the location of the wireless communication device in addition to the change in three-dimensional orientation of the wireless communication device to alter the three-dimensional direction that the directional beam is pointing.

**5**. The wireless communication device of claim **2** wherein the beam-altering module is configured to determine the direction from the wireless communication device toward the base transceiver station based on strengths of received signals from different receive paths.

**6**. The wireless communication device of claim **1** wherein the three-dimensional orientation sensor module comprises (1) a three-dimensional gyroscope sensor, or (2) a three-dimensional compass and a gravity sensor, or both.

**7**. The wireless communication device of claim **1** wherein the beam-altering module comprises a beam-forming module and the antenna module includes a phased-array antenna comprising a plurality of antenna elements and a phase module configured to set phases for corresponding ones of the plurality of antenna elements to point the directional beam in a desired direction.

**8**. The wireless communication device of claim **1** wherein the beam-altering module comprises a beam-steering module including an antenna direction controller configured to direct the directional beam provided by the antenna module.

**9**. The wireless communication device of claim **1** wherein the beam-altering module includes a beam width controller configured to adjust a width of the directional beam in response to movement of the device indicated by the three-dimensional orientation sensor module.

**10**. A mobile wireless communication device comprising:

an antenna module configured to provide an antenna pattern having a directional beam to transmit electromagnetic energy of outgoing communication signals for reception by a base transceiver station and to receive electromagnetic energy of incoming signals from the base transceiver station;

direction means for determining a direction of the base transceiver station relative to the communication device;

orientation means for obtaining three-dimensional orientation information for the communication device indicative of a three-dimensional orientation of the wireless communication device

direction means for determining, based on the orientation information, a desired change in three-dimensional direction of a directional beam provided by the orientation means of the wireless communication device in order to compensate for a change in three-dimensional orientation of the wireless communication device; and

altering means for causing the antenna module to change a three-dimensional direction that the directional beam is pointing based on the determined desired change in three-dimensional direction of the directional beam.

**11**. The wireless communication device of claim **10** wherein the orientation information for the wireless communication device indicates a three-dimensional orientation of the wireless communication device, the direction means including a satellite positioning system module configured to determine a location of the wireless communication device, and wherein the altering means are further for determining a location of the base transceiver station and determining the direction from the wireless communication device toward the base transceiver station using the location of the wireless communication device, the location of the base transceiver station, and the three-dimensional orientation of the wireless communication device.

**12**. The wireless communication device of claim **10**, the direction means including a satellite positioning system module configured to determine a location of the wireless communication device, and wherein the altering means are further for using the location of the wireless communication device in addition to the orientation information to alter the three-dimensional direction that the directional beam is pointing.

**13**. The wireless communication device of claim **10** wherein the direction means are configured to determine the direction of the base transceiver station relative to the wireless communication device based on strengths of received signals at the wireless communication device from different receive paths.

**14**. The wireless communication device of claim **10** wherein the altering means include a beam-forming module and the antenna module includes a phased-array antenna comprising a plurality of antenna elements and a phase module configured to set phases for corresponding ones of the plurality of antenna elements to point the directional beam in a desired direction.

**15**. The wireless communication device of claim **10** wherein the altering means comprise a beam-steering module configured to redirect the directional beam provided by the antenna module.

**16**. The wireless communication device of claim **10** wherein the altering means are further for adjusting a width of the directional beam in response to movement of the device indicated by the orientation means.

**17**. A computer program product residing on a non-transitory processor-readable medium and comprising processor-readable instructions configured to cause a processor to:

obtain three-dimensional orientation information for the wireless communication device indicative of a three-dimensional orientation of a wireless communication device;

determine, based on the orientation information, a desired change in three-dimensional direction of a directional beam provided by an antenna module of the wireless communication device in order to compensate for a change in three-dimensional orientation of the wireless communication device; and

cause the antenna module to change a three-dimensional direction that the directional beam is pointing based on the determined desired change in three-dimensional direction of the directional beam.

**18**. The computer program product of claim **17** wherein the orientation information is present orientation information indicative of a present orientation of the wireless communication device and wherein the instructions configured to cause the processor to determine the desired change are configured to cause the processor to analyze a previous orientation of the wireless communication device indicated by previous orientation information and the present orientation of the wireless communication device indicated by the present orientation information to determine a change in orientation of the wireless communication device.

**19**. The computer program product of claim **17** wherein the instructions configured to cause the processor to determine the desired change are configured to cause the processor to account for available directions of the directional beam achievable by the antenna module of the wireless communication device.

**20**. The computer program product of claim **17** further comprising instructions configured to cause the processor to:

obtain a location of the wireless communication device;

obtain a location of the base transceiver station; and

determine a direction from the wireless communication device toward the base transceiver station using the location of the device, the location of the base transceiver station, and the orientation of the communication device.

**21**. The computer program product of claim **20** wherein the instructions configured to cause the processor to obtain the location of the wireless communication device are configured to cause the processor to analyze satellite positioning system signals to obtain the location of the wireless communication device.

**22**. The computer program product of claim **17** wherein the orientation information is indicative of a change in three-dimensional orientation of the wireless communication device, the instructions further comprising instructions configured to cause the processor to obtain a location of the wireless communication device, and the instructions configured to cause the processor to determine the desired change are configured to cause the processor to use the location of the wireless communication device in addition to the three-dimensional orientation information.

**23**. The computer program product of claim **17** further comprising instructions configured to cause the processor to determine a direction from the wireless communication device toward a base transceiver station based on strengths of received signals at the wireless communication device from the base transceiver station over different receive paths.

**24**. The computer program product of claim **17** wherein the instructions configured to cause the processor to cause the antenna module to change a three-dimensional direction that the directional beam is pointing are configured to cause the processor cause a change in phase of at least one radiating element of a phased-array antenna of the antenna module.

**25**. The computer program product of claim **17** wherein the instructions configured to cause the processor to cause the antenna module to change a three-dimensional direction that the directional beam is pointing are configured to cause a beam steering of the directional beam provided by the antenna module.

**26**. A method of affecting a direction of a mobile wireless communication device antenna, the method comprising:

obtaining a first direction of a base transceiver station relative to the mobile wireless communication device;

obtaining a three-dimensional orientation of the mobile wireless communication device from at least one orientation sensor of the mobile wireless communication device;

determining a second direction of the base transceiver station relative to the three-dimensional orientation of the mobile wireless communication device based upon the first direction and the three-dimensional orientation of the mobile wireless communication device; and

setting a three-dimensional beam direction of an antenna beam of an antenna of the mobile wireless communication device according to the second direction.

**27**. The method of claim **26** wherein obtaining the orientation of the mobile wireless communication device comprises obtaining a change in the orientation of the mobile wireless communication device and setting the beam direction comprises causing a change in a present beam direction according to the change in the orientation.

**28**. The method of claim **26** wherein obtaining the orientation comprises at least one of (1) obtaining three-dimensional gyroscope information or (2) obtaining three-dimensional compass information and gravity direction information.

**29**. The method of claim **26** wherein obtaining the first direction comprises at least one of (1) obtaining a location of the mobile wireless communication device using satellite positioning system signals or (2) analyzing strengths of signals received by the mobile wireless communication device from the base transceiver station.

**30**. The method of claim **26** wherein setting the beam direction comprises beam-forming the antenna beam.

**31**. The method of claim **26** wherein setting the beam direction comprises beam-steering the antenna beam.

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